JAPAN INTERNATIONAL COOPERATION AGENCY
KATAHIRA & ENGINEERS
INTERNATIONAL

	DESIGNED BY	CHECKED BY	SUBMITTED BY
Name	A. GOURLEY	T. OKUMURA	M. KIUCHI
Sign			
Date			

REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HIGHWAYS

APPROVED BY: Ir. HERRY VAZA M,Eng.Sc
NIP. : 110038400
Sign
Date

PROJECT AND LOCATION :
DETAILED DESIGN STUDY OF
NORTH JAVA CORRIDOR FLYOVER PROJECT
BALARAJA FLYOVER - CONTRACT PACKAGE 1
(MERAK - BALARAJA)
BANTEN PROVINCE

SCALE :
1 : 40
1 : 60
1 : 150
1 : 4000
FULL SIZE A3

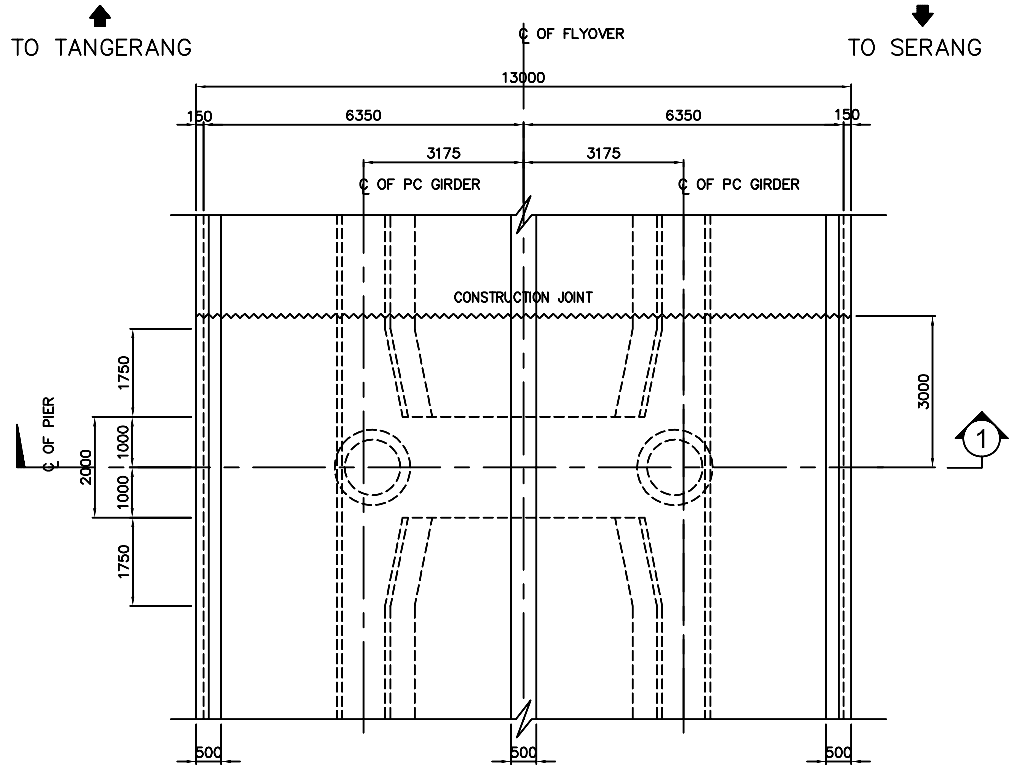
DRAWING TITLE :

PIER LAYOUT
P8,P9 (FIXED)

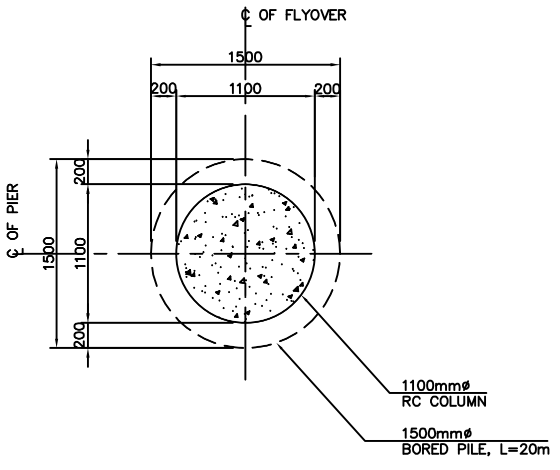
DRAWING NO : BSB-07
SHEET NO : 07 / 44

SCHEDULE OF PIERS (FIXED)

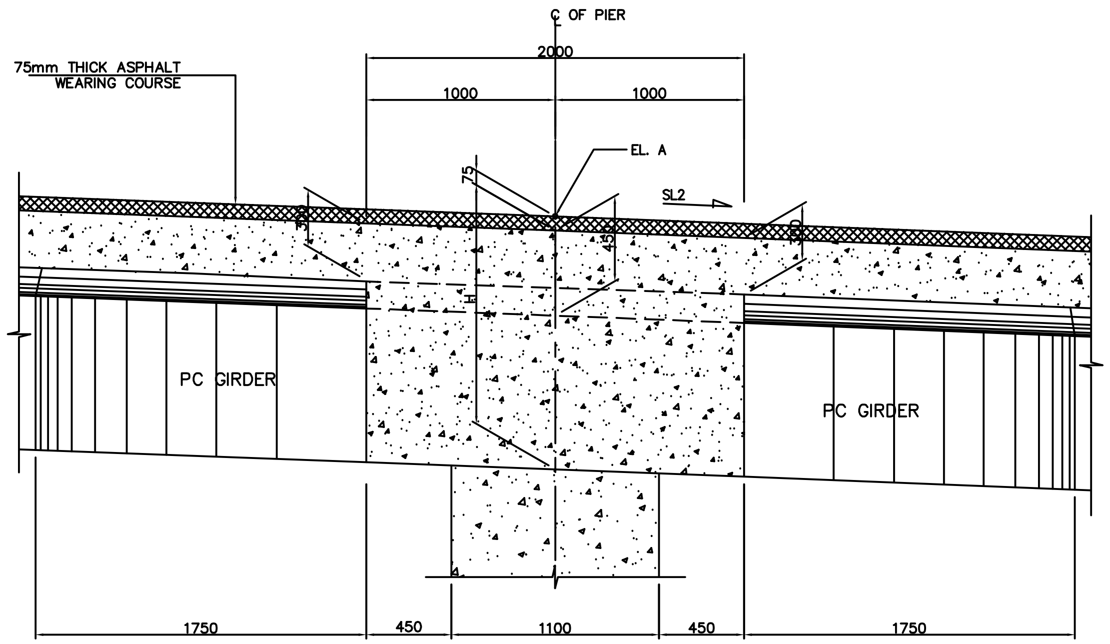
PIER	EL A	EL AL	EL AR	EL BL	EL BR	SL 1L	SL 1R	SL2	H	HL	HR	H1	H2	H3	H4	H5	H6
P8	27.090	27.187	26.993	18.815	18.815	+3.057%	−3.057%	−5.730%	1200	7097	6903	1103	1297	734	766	369	531
P9	26.207	26.371	26.043	17.932	17.932	+5.171%	−5.171%	−5.730%	1200	7164	6836	1036	1364	723	777	313	587



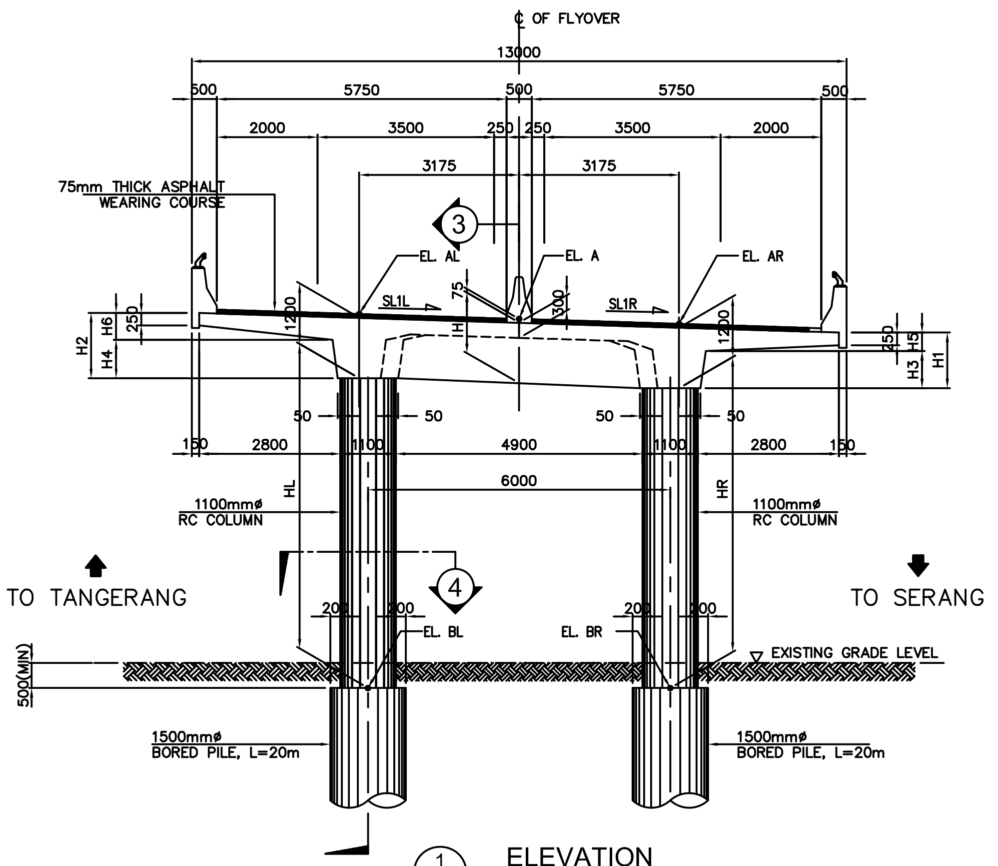
2 - P L A N
SCALE : 1:150



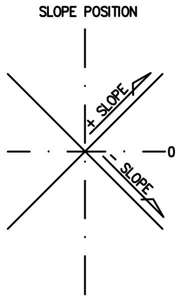
4 - SECTION
SCALE : 1:60

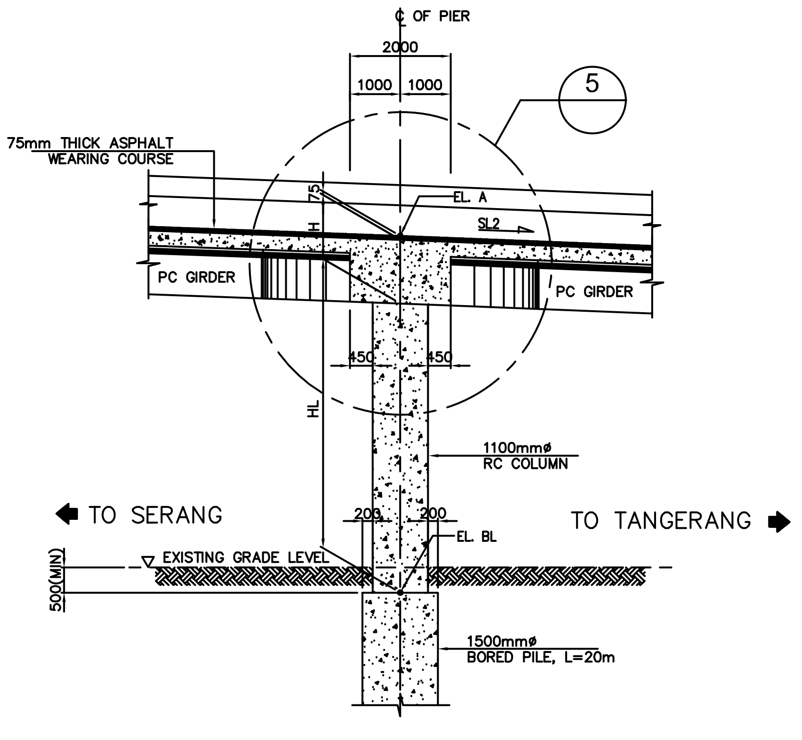


5 - D E T A I L
SCALE : 1:40



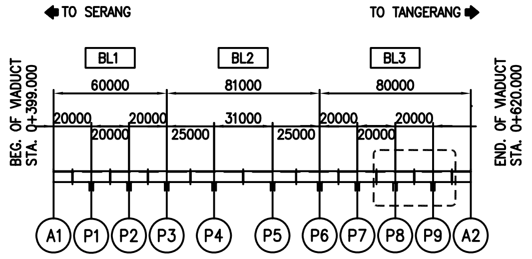
1 - ELEVATION
SCALE : 1:150





3 - SECTION
SCALE : 1:150

NOTES :
1. ALL DIMENSIONS ARE IN MILLIMETER
2. ELEVATIONS ARE IN METERS



* - KEY PLAN
SCALE : 1:4000

JAPAN INTERNATIONAL COOPERATION AGENCY
KATAHIRA & ENGINEERS
INTERNATIONAL

	DESIGNED BY		CHECKED BY		SUBMITTED BY
Name	R. UENO	Name	S. GOSE	Name	M. KIUCHI
Sign		Sign		Sign	
Date		Date		Date	

REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HIGHWAYS

APPROVED BY	Ir. HERRY VAZA M,Eng.Sc	Sign	
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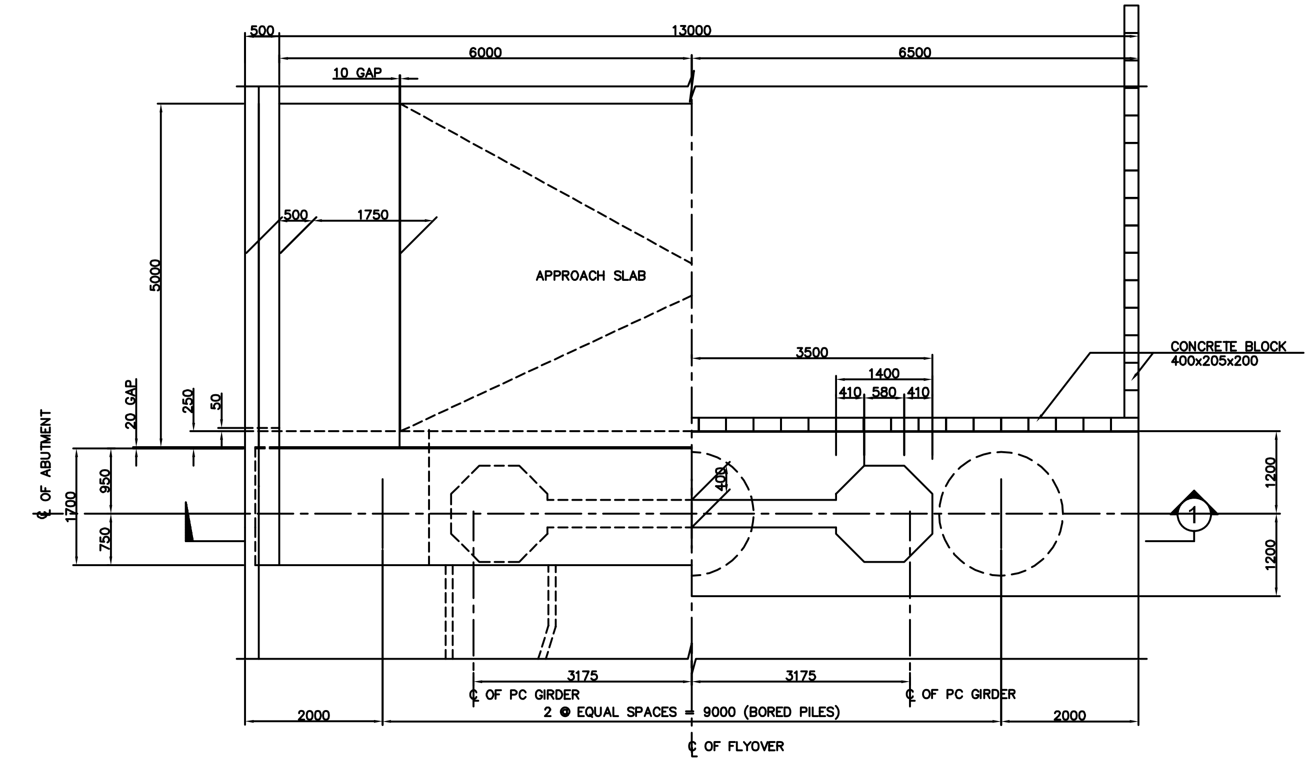
PROJECT AND LOCATION :
DETAILED DESIGN STUDY OF
NORTH JAVA CORRIDOR FLYOVER PROJECT
BALARAJA FLYOVER - CONTRACT PACKAGE 1
(MERAK - BALARAJA)
BANTEN PROVINCE

SCALE :
1 : 75
1 : 20
FULL SIZE A3

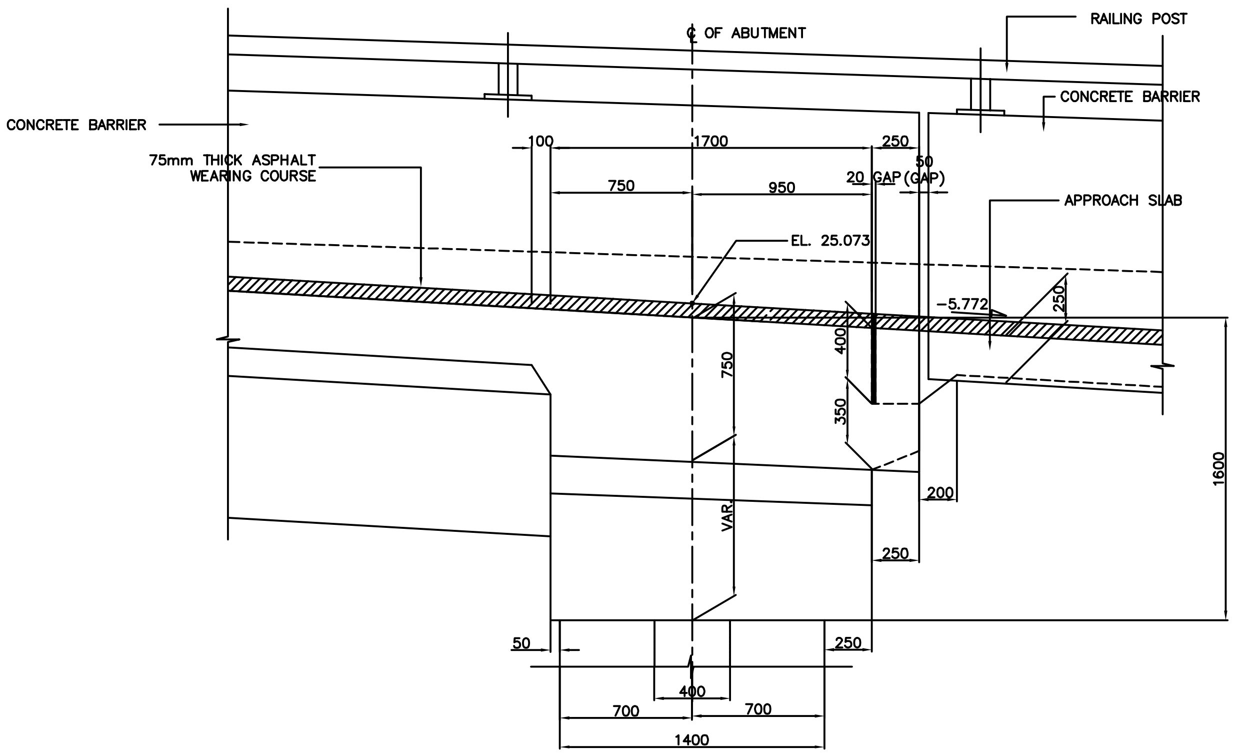
DRAWING TITLE :

ABUTMENT LAYOUT & DIMENSIONS (ABUT. A2)

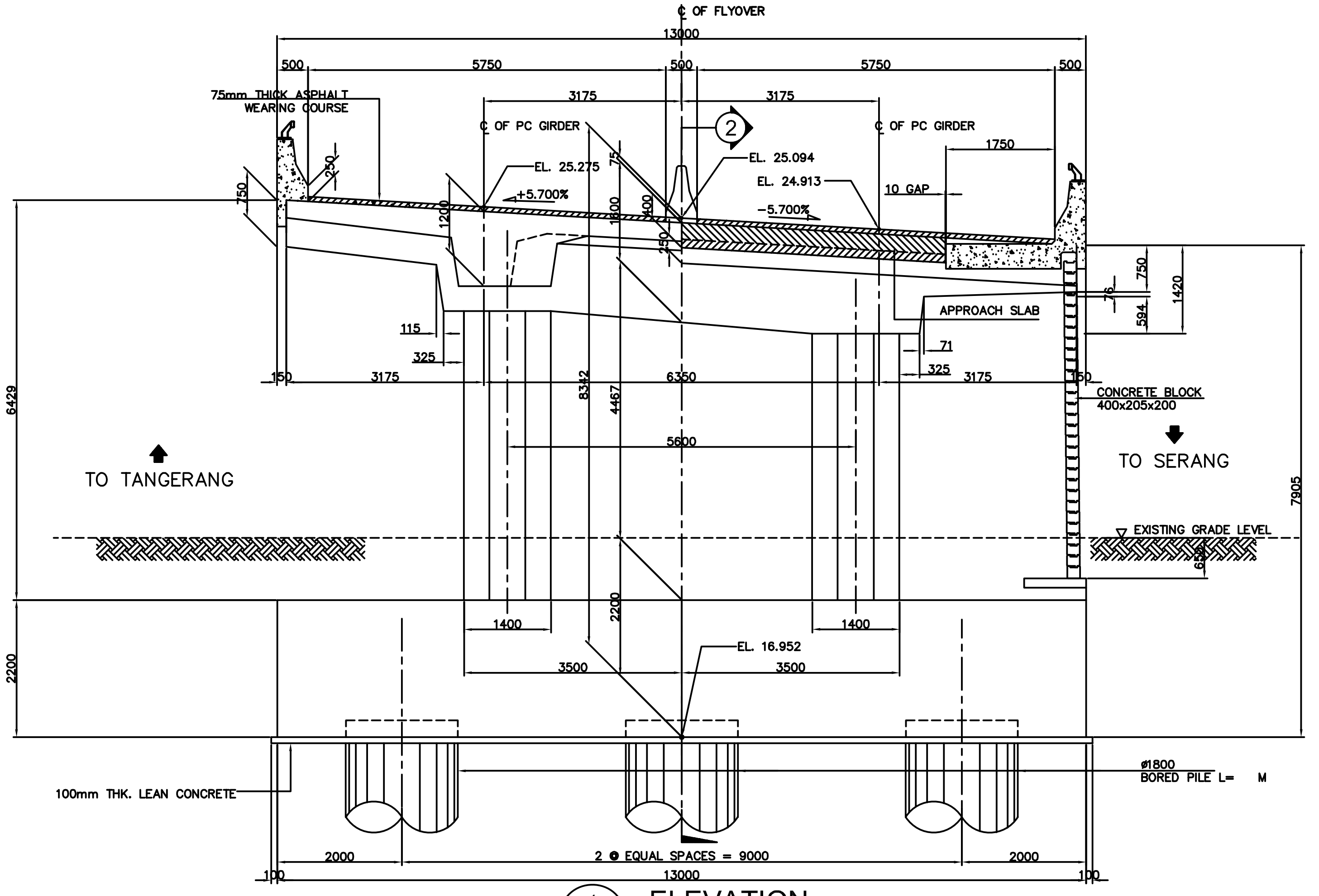
DRAWING NO :
000-000
SHEET NO :
01 / 001



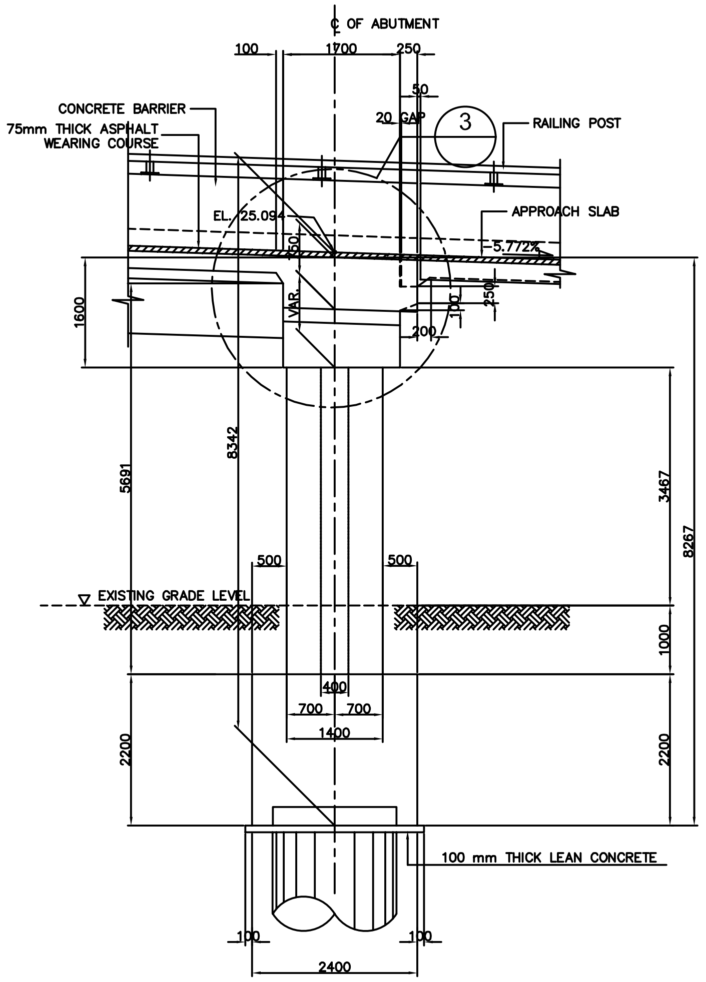
A PLAN
SCALE 1:75



3 DETAIL
SCALE 1:20



1 ELEVATION
SCALE 1:75

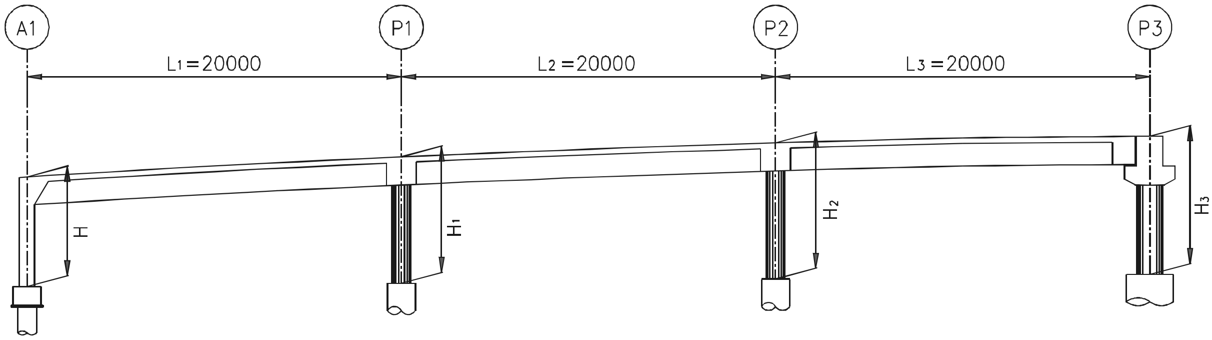


NOTES :
1. ALL DIMENSIONS ARE IN MILLIMETER
2. ELEVATIONS ARE IN METERS

2 SECTION
SCALE 1:75

1. ARRANGEMENT

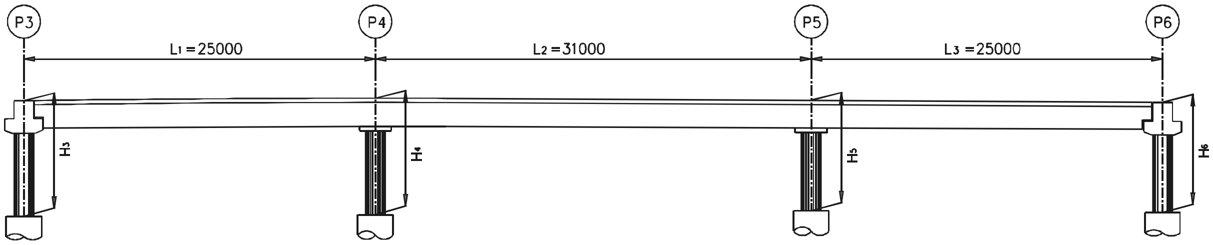
a. Frame A1-P3



L_1 = 20 m
L_2 = 20 m
L_3 = 20 m

H = 5.23 m
H_1 = 8.29 m
H_2 = 8.29 m
H_3 = 8.39 m

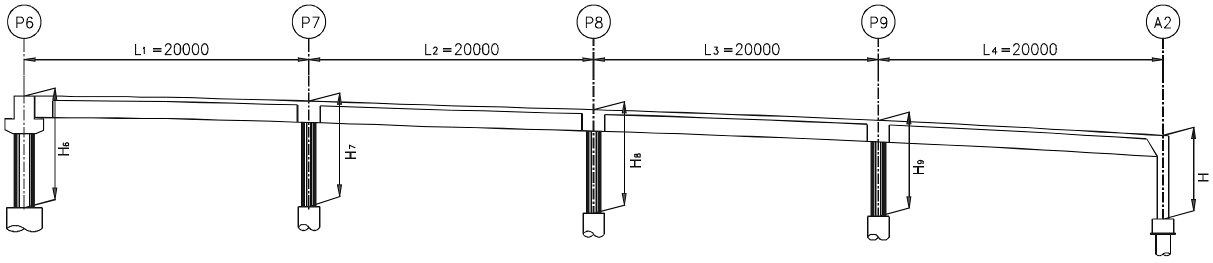
b. Frame P3-P6



L_1 = 25 m
L_2 = 31 m
L_3 = 25 m

H_3 = 8.39 m
H_4 = 8.5 m
H_5 = 8.5 m
H_6 = 8.9 m

c. Frame P6-A2



L_1 = 20 m
L_2 = 20 m
L_3 = 20 m
L_4 = 20 m

H_6 = 8.9 m
H_7 = 8.2 m
H_8 = 8.2 m
H_9 = 8.2 m
H = 4.47 m

2. SECTION PROPERTIES and MATERIAL PROPERTIES

2.1 CONCRETE DECK SECTION PROPERTIES

BALARAJA FLYOVER

NO	ELEMENT	SAP REFERENCE	Area A (m2)	Moment of Inersia Ixx (m4)	Moment of Inersia Iyy (m4)	Torsional Constans C (m4)
1	Abutment	ABUT	5.328	0.5756	30.8814	1.074
2	Footing Abutment	FOOT	4.8	0.5756	2.304	3.175
3	Composite Column 140 cm Dia	C140COMPOSITE	2.1377	0.337	0.337	0.708
4	Composite Bored Pile 250 cm Dia	COMPBP250	5.5802	2.441	2.441	5.094
5	Composite Deck	COMP-DECK	5.512	2.267	81.278	0.8198
6	Concrete Deck Slab	DECKCON	5.8922	0.5579	73.922	0.457

Joint Masses

Pier Location	Joint mass	Joint Load
	kN.s/m^2	kN
A1	31.5	280
P1	Include in model	Include in model
P2	Include in model	Include in model
P3	114.86	1021.8
P4	15	147
P5	15	147
P6	Include in model	Include in model
P7	Include in model	Include in model
P8	Include in model	Include in model
P9	Include in model	Include in model
P10	Include in model	Include in model
A2	31.5	280

BALARAJA CONCRETE DECK SECTION PROPERTIES

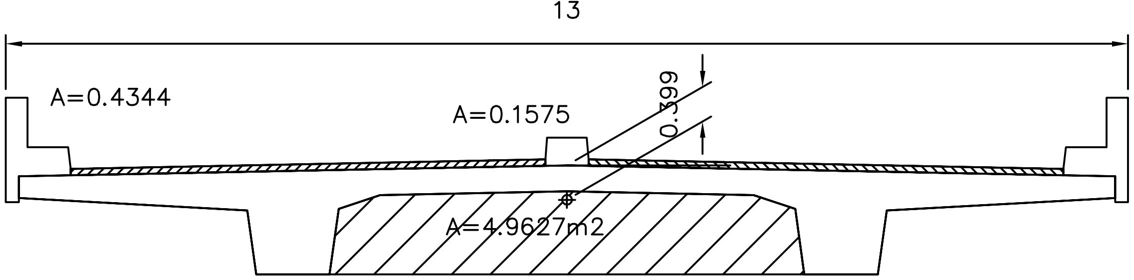
IN SPAN

```
----  REGIONS AGAINS CL TOP SLAB   -------

Area:                      5.8985
Perimeter:                 28.5701
Bounding box:           X: -6.3500  --  6.3500
                        Y: -1.2635  --  0.0000
Centroid:               X: 0.0000
                        Y: -0.3988
Moments of inertia:     X: 1.4962
                        Y: 73.9223
Product of inertia:    XY: 0.0000
Radii of gyration:      X: 0.5036
                        Y: 3.5401
```

```
-----REGIONS AGAINS CG OF STRUCTURE-------

Area:                      5.8985
Perimeter:                 28.5701
Bounding box:           X: -6.3500  --  6.3500
                        Y: -0.8647  --  0.3988
Centroid:               X: 0.0000
                        Y: 0.0000
Moments of inertia:     X: 0.5580
                        Y: 73.9223
Product of inertia:    XY: 0.0000
Radii of gyration:      X: 0.3076
                        Y: 3.5401
```



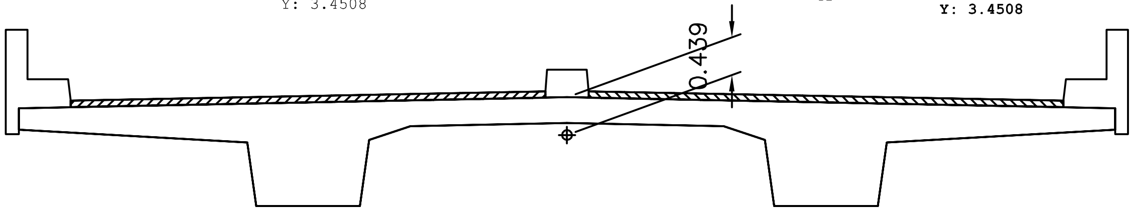
@ SUPPORT

```
-----REGIONS AGAINS CL TOP SLAB------

Area:                      6.5374
Perimeter:                 28.5843
Bounding box:           X: -6.3500  --  6.3500
                        Y: -1.2635  --  0.0000
Centroid:               X: 0.0000
                        Y: -0.4386
Moments of inertia:     X: 1.9560
                        Y: 77.8467
Product of inertia:    XY: 0.0000
Radii of gyration:      X: 0.5470
                        Y: 3.4508
```

```
------REGIONS AGAINS CG OF STRUCTURE-----

Area:                      6.5374
Perimeter:                 28.5843
Bounding box:           X: -6.3500  --  6.3500
                        Y: -0.8249  --  0.4386
Centroid:               X: 0.0000
                        Y: 0.0000
Moments of inertia:     X: 0.6984
                        Y: 77.8467
Product of inertia:    XY: 0.0000
Radii of gyration:      X: 0.3269
                        Y: 3.4508
```



D:\...BALARAJA-FINAL UNTIL - 01-07-06-READ REVISION NOTES.dwg\secp4.dwg, 9/16/2006 6:49:00 PM

DRAWING NO. :

DATE :

DRAWING TITLE :

DETAILED DESIGN

KATAHIRA & ENGINEERS
INTERNATIONAL

DETAILED DESIGN STUDY
OF
NORTH JAVA CORRIDOR FLYOVER PROJECT
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

2.2 STEEL DECK SECTION PROPERTIES

JICA JAPAN INTERNATIONAL COOPERATION AGENCY	DETAILED DESIGN STUDY OF NORTH JAVA CORRIDOR FLYOVER PROJECT IN THE REPUBLIC OF INDONESIA	DETAILED DESIGN KATAHIRA & ENGINEERS INTERNATIONAL	DRAWING TITLE :	DRAWING NO. : DATE :

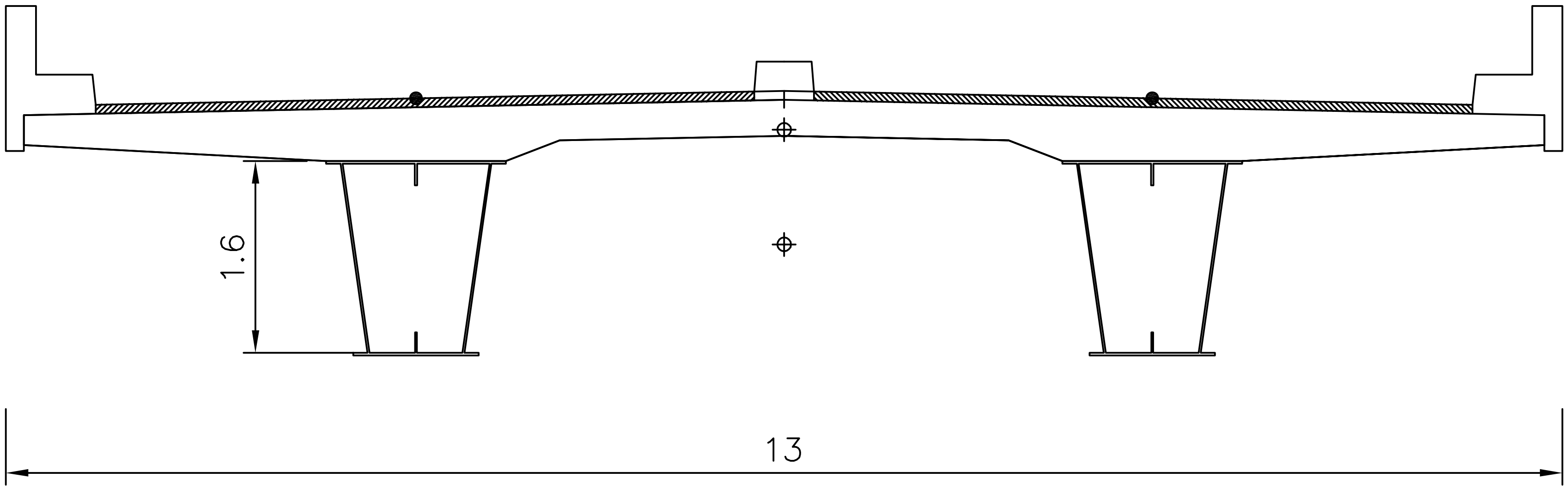
COMPOSITE GIRDER BALARAJA FLYOVER

```
-----REGION TWIN STEEL BOX GIRDER AGAINST CL TOP
SLAB-----

Area:                     0.2235
Perimeter:               24.3989
Bounding box:         X: -3.8250  --  3.8250
                      Y: -2.1335  --  -0.5115
Centroid:             X: 0.0000
                      Y: -1.2576
Moments of inertia:   X: 0.4497
                      Y: 2.1564
Product of inertia:  XY: 0.0000
Radii of gyration:    X: 1.4185
                      Y: 3.1061
```

```
-------CONCRETE DECK SLAB AGAINST CL TOP SLAB-------

Area:                     4.5486
Perimeter:               25.9754
Bounding box:         X: -6.3485  --  6.3515
                      Y: -0.5115  --  0.0000
Centroid:             X: 0.0000
                      Y: -0.2492
Moments of inertia:   X: 0.3472
                      Y: 59.5008
Product of inertia:  XY: -0.0017
Radii of gyration:    X: 0.2763
                      Y: 3.6168
```



2.3 COMPOSITE COLUMN AND COMPOSITE PILE TOP SECTION PROPERTIES

KATAHIRA & ENGINEERS
INTERNATIONAL

Project: **Detailed Design Study of**
North Java Corridor Flyover Project

Calculation: **Detailed Design Substructure**
Balaraja Flyover
Composite Bored Piles & Coloumn Torsion Properties

Initial Data

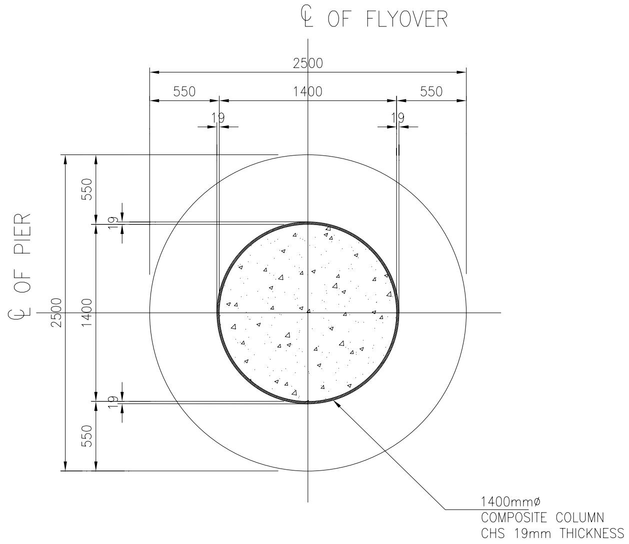
Modulus of elasticity of steel $E_s := 200000 \cdot MPa$

Characteristic strength of RC concrete $f_c := 30 \cdot MPa$

Modulus of elasticity of concrete $E_c := 4700 \cdot \sqrt{\frac{f_c}{MPa}} \cdot MPa$ $E_c = 25743\,MPa$

Modular ratio wth respect to concrete $\alpha_c := \frac{E_s}{E_c}$ $\alpha_c = 7.769$

Coposite Coloumn Dia 140 cm section properties respect to center point



Solid Concrete Coloumn diameter $D_c := 1.4m$

Casing thicknes $t_s := 19mm$

Steel Casing Outer Diameter $D_s := D_c + 2.t_s$

$D_s = 1.438\ m$

Area of solid Concrete

$$A_c := \frac{1}{4} \cdot \pi \cdot D_c^{\,2}$$

$$A_c = 1.539 \text{ m}^2$$

Area of Steel Casing

$$A_s := \frac{1}{4} \pi \cdot \left(D_s^{\,2} - D_c^{\,2} \right)$$

$$A_s = 0.085 \text{ m}^2$$

Combined Area - stress

$$A_{comp} := A_c + A_s \cdot \alpha_c$$

$$A_{comp} = 2.197 \text{ m}^2$$

Stiffness of Concrete Solid Circle

$$I_c := \frac{1}{64} \cdot \pi \cdot D_c^{\,4}$$

Stiffness Steel Casing

$$I_s := \frac{1}{64} \cdot \pi \cdot \left(D_s^{\,4} - D_c^{\,4} \right)$$

$$I_s = 0.021 \text{ m}^4$$

Combine stiffness Coloumn wrt to Concrete Ixx - Iyy

$$I_{comp} := I_c + I_s \cdot \alpha_c$$

$$I_{comp} = 0.354 \text{ m}^4$$

Torsional Constant Solid Concrete Circle

$$K_c := \frac{1}{2} \pi \cdot \left(\frac{D_c}{2} \right)^4$$

$$K_c = 0.377 \text{ m}^4$$

Torsional Constant Steel Casing Hollow concentric circular

$$K_s := \frac{1}{2} \pi \cdot \left[\left(\frac{D_s}{2} \right)^4 - \left(\frac{D_c}{2} \right)^4 \right]$$

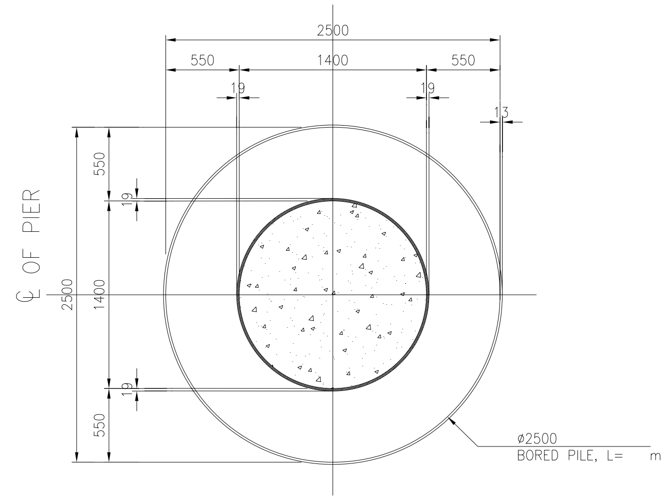
$$K_s = 0.043 \text{ m}^4$$

Combined Torsional constant wrt to concrete

$$K_{comp} := K_c + K_s \cdot \alpha_c$$

$$K_{comp} = 0.708 \text{ m}^4$$

Coposite Bored Piles Dia 250 cm section properties respect to center point

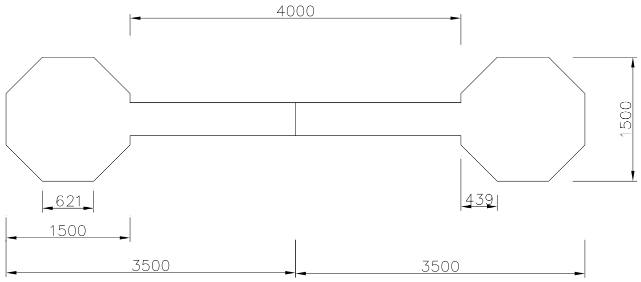


Solid Concrete Coloumn diameter	$D_c := 2.5m$
Casing thicknes	$t_s := 13mm$
Steel Casing Outer Diameter	$D_s := D_c + 2.t_s$
	$D_s = 2.526\ m$
Area of solid Concrete	$A_c := \frac{1}{4} \cdot \pi \cdot D_c^{2}$
	$A_c = 4.909\ m^{2}$
Area of Steel Casing	$A_s := \frac{1}{4} \pi \cdot \left(D_s^{2} - D_c^{2}\right)$
	$A_s = 0.103\ m^{2}$
Combined Area - stress	$A_{comp} := A_c + A_s \cdot \alpha_c$
	$A_{comp} = 5.706\ m^{2}$
Stiffness of Concrete Solid Circle	$I_c := \frac{1}{64} \cdot \pi \cdot D_c^{4}$
Stiffness Steel Casing	$I_s := \frac{1}{64} \cdot \pi \cdot \left(D_s^{4} - D_c^{4}\right)$
	$I_s = 0.081\ m^{4}$

2.4. ABUTMENT AND PIER COPING SECTION PROPERTIES

Project: **Detailed Design Study of North Java Corridor Flyover Project**

Calculation: **Detailed Design Substructure Balaraja Flyover Abutment Section Properties & Torsion Properties**



```
 ----------------   REGIONS   ----------------

Area:                    5.3281
Perimeter:               17.1414
Bounding box:         X: -3.5000  --  3.5000
                      Y: -0.7500  --  0.7500
Centroid:             X: 0.0000
                      Y: 0.0000
Moments of inertia:   X: 0.5756
                      Y: 30.8814
Product of inertia:  XY: 0.0000
Radii of gyration:    X: 0.3287
                      Y: 2.4075
```

Torsional Constant based on Circular & Rectangular Section:

$r := \frac{1}{2} \cdot 1.5m$ $\qquad a := \frac{1}{2} \cdot 4.0m$ $\qquad b := \frac{1}{2} \cdot 0.4m$

Circle Section :

$$CC := \frac{1}{2} \pi \cdot r^4$$

$$CC = 0.497\ m^4$$

Rectangular Section :

$$CR := a \cdot b^3 \left[\frac{16}{3} - 3.36 \cdot \frac{b}{a} \left(1 - \frac{b^4}{12 \cdot a^4} \right) \right]$$

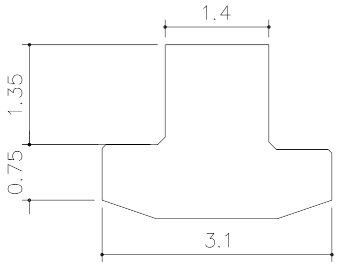
$$CR = 0.08\ m^4$$

$$C_{ABT} := 2CC + CR$$

$$C_{ABT} = 1.074\ m^4$$

```
 ------REGION COPING EXPANSION------

Area:                      4.7596
Perimeter:                 10.3081
Bounding box:         X: -1.5500  --  1.5500
                      Y: -2.3503  --  0.0000
Centroid:             X: -0.0131
                      Y: -1.3722
Moments of inertia:   X: 10.9877
                      Y: 2.3998
Product of inertia:  XY: 0.0864
Radii of gyration:    X: 1.5194
                      Y: 0.7101
```



$$a_1 := \frac{1}{2}1.4\text{m} \qquad b_1 := \frac{1}{2}1.35\text{m}$$

$$a_2 := \frac{1}{2}\cdot 3.1\text{m} \qquad b_2 := \frac{1}{2}\cdot 0.75\text{m}$$

Rectangular Section :

$$CR_1 := a_1 \cdot b_1^{\,3}\left[\frac{16}{3} - 3.36\cdot\frac{b_1}{a_1}\left(1 - \frac{b_1^{\,4}}{12\cdot a_1^{\,4}}\right)\right]$$

$$CR_1 = 0.501\ \text{m}^4$$

Rectangular Section :

$$CR_2 := a_2 \cdot b_2^{\,3}\left[\frac{16}{3} - 3.36\cdot\frac{b_2}{a_2}\left(1 - \frac{b_2^{\,4}}{12\cdot a_2^{\,4}}\right)\right]$$

$$CR_2 = 0.37\ \text{m}^4$$

$$CR := CR_1 + CR_2$$

$$CR = 0.87\ \text{m}^4$$

MASS OF COPING

$$A := 4.756\text{m}^2 \qquad L := 7.25\text{m}$$

$$MASS := A\cdot L\cdot 2.5\frac{\text{ton}}{\text{m}^3}$$

$$MASS = 86.203\,\text{ton}$$

2.5. TORSION PROPERTIES

KATAHIRA & ENGINEERS
INTERNATIONAL

Project: **Detailed Design Study of North Java Corridor Flyover Project**

Calculation: **Detailed Design Substructure**
Balaraja Flyover
Torsion Properties

Initial Data

Modulus of elasticity of steel $E_s := 200000 \cdot \mathrm{MPa}$

Characteristic strength of RC concrete $f_c := 30 \cdot \mathrm{MPa}$

Modulus of elasticity of concrete $E_c := 4700 \cdot \sqrt{\dfrac{f_c}{\mathrm{MPa}}} \cdot \mathrm{MPa}$ $E_c = 25743\,\mathrm{MPa}$

Modular ratio wth respect to concrete $\alpha_c := \dfrac{E_s}{E_c}$ $\alpha_c = 7.769$

For rectangular sections torsion constant is calculated as follows:

Torsional constant

$$C(k1, b, b_{max}) := k1 \cdot b^3 \cdot b_{max}$$

where k1 factor

$$k1(b_{max}, b) := \left| \begin{array}{l} \mathrm{ratio} \leftarrow \dfrac{b_{max}}{b} \\ 0.141 \text{ if } \mathrm{ratio} = 1.0 \\ 0.154 \text{ if } (\mathrm{ratio} \le 1.2)\cdot(\mathrm{ratio} > 1.0) \\ 0.166 \text{ if } (\mathrm{ratio} \le 1.3)\cdot(\mathrm{ratio} > 1.2) \\ 0.175 \text{ if } (\mathrm{ratio} \le 1.4)\cdot(\mathrm{ratio} > 1.3) \\ 0.186 \text{ if } (\mathrm{ratio} \le 1.5)\cdot(\mathrm{ratio} > 1.4) \\ 0.196 \text{ if } (\mathrm{ratio} \le 1.8)\cdot(\mathrm{ratio} > 1.5) \\ 0.216 \text{ if } (\mathrm{ratio} \le 2.0)\cdot(\mathrm{ratio} > 1.8) \\ 0.229 \text{ if } (\mathrm{ratio} \le 2.3)\cdot(\mathrm{ratio} > 2.0) \\ 0.242 \text{ if } (\mathrm{ratio} \le 2.5)\cdot(\mathrm{ratio} > 2.3) \\ 0.249 \text{ if } (\mathrm{ratio} \le 2.8)\cdot(\mathrm{ratio} > 2.5) \\ 0.258 \text{ if } (\mathrm{ratio} \le 3.0)\cdot(\mathrm{ratio} > 2.8) \\ 0.263 \text{ if } (\mathrm{ratio} \le 4.0)\cdot(\mathrm{ratio} > 3.0) \\ 0.281 \text{ if } (\mathrm{ratio} \le 5.0)\cdot(\mathrm{ratio} > 4.0) \\ 0.305 \text{ if } (\mathrm{ratio} \le 7.5)\cdot(\mathrm{ratio} > 5.0) \\ 0.312 \text{ if } (\mathrm{ratio} \le 10.0)\cdot(\mathrm{ratio} > 7.5) \\ 0.333 \text{ otherwise} \end{array} \right.$$

For "thin walled" sections" box sections torsion constant is calculated as follows

$j := 1 .. 4$

$$CS(A, ds, t) := \frac{4 \cdot A^2}{\displaystyle\sum_j \frac{ds_j}{t_j}}$$

PC DOUBLE GIRDER DECK - 20m Span

In Span Section

Girder Section

Effective length of short side $b := 955 \cdot mm$

Effective length of long side $b_{max} := 1200 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.166$

$C1 := C(k, b, b_{max})$

$C1 = 0.173\ m^4$

Cantilever Slab

Effective length of short side $b := 350 \cdot mm$

Effective length of long side $b_{max} := 2645 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.312$

$C2 := C(k, b, b_{max})$

$C2 = 0.035\ m^4$

Central Slab

Effective length of short side $b := 300 \cdot mm$

Effective length of long side $b_{max} := 2195 \cdot 2 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.333$

$C3 := C(k, b, b_{max})$

$C3 = 0.039\ m^4$

Total torsional constant $C_{SPAN} := C1 \cdot 2 + C2 \cdot 2 + C3$

$C_{SPAN} = 0.457\ m^4$

At Pier Section

Girder Section

Effective length of short side $b := 1200 \cdot mm$

Effective length of long side $b_{max} := 1460 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.166$

$C1 := C(k, b, b_{max})$

$C1 = 0.419\ m^4$

Cantilever Slab

Effective length of short side $b := 325 \cdot mm$

Effective length of long side $b_{max} := 2265 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.305$

$C2 := C(k, b, b_{max})$

$C2 = 0.024\ m^4$

Central Slab

Effective length of short side $b := 270 \cdot mm$

Effective length of long side $b_{max} := 2630 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.312$

$C3 := C(k, b, b_{max})$

$C3 = 0.016\ m^4$

Total torsional constant

$C_{PIER} := C1 \cdot 2 + C2 \cdot 2 + C3$

$C_{PIER} = 0.901\ m^4$

At Diaphragm Section

Girder Section

Effective length of short side $b := 1200 \cdot mm$

Effective length of long side $b_{max} := 6560 \cdot mm$

$k := k1\left(b_{max}, b\right)$ $k = 0.305$

$C1 := C\left(k, b, b_{max}\right)$

$C1 = 3.457\ m^4$

Cantilever Slab

Effective length of short side $b := 325 \cdot mm$

Effective length of long side $b_{max} := 2265 \cdot mm$

$k := k1\left(b_{max}, b\right)$ $k = 0.305$

$C2 := C\left(k, b, b_{max}\right)$

$C2 = 0.024\ m^4$

Total torsional constant

$C_{total} := C1 + C2 \cdot 2$

$C_{total} = 3.505\ m^4$

KATAHIRA & ENGINEERS
INTERNATIONAL

Project: **Detailed Design Study of North Java Corridor Flyover Project**

Calculation: **Detailed Design Substructure**
Balaraja Flyover
Torsion Properties

Initial Data

Modulus of elasticity of steel $E_s := 200000 \cdot MPa$

Characteristic strength of RC concrete $f_c := 30 \cdot MPa$

Modulus of elasticity of concrete $E_c := 4700 \cdot \sqrt{\frac{f_c}{MPa}} \cdot MPa$ $E_c = 25743\,MPa$

Modular ratio wth respect to concrete $\alpha_c := \frac{E_s}{E_c}$ $\alpha_c = 7.769$

For rectangular sections torsion constant is calculated as follows:

Torsional constant

$$C(k1, b, b_{max}) := k1 \cdot b^3 \cdot b_{max}$$

where k1 factor

$$k1(b_{max}, b) := \left| \begin{array}{l} ratio \leftarrow \frac{b_{max}}{b} \\ 0.141 \text{ if } ratio = 1.0 \\ 0.154 \text{ if } (ratio \le 1.2) \cdot (ratio > 1.0) \\ 0.166 \text{ if } (ratio \le 1.3) \cdot (ratio > 1.2) \\ 0.175 \text{ if } (ratio \le 1.4) \cdot (ratio > 1.3) \\ 0.186 \text{ if } (ratio \le 1.5) \cdot (ratio > 1.4) \\ 0.196 \text{ if } (ratio \le 1.8) \cdot (ratio > 1.5) \\ 0.216 \text{ if } (ratio \le 2.0) \cdot (ratio > 1.8) \\ 0.229 \text{ if } (ratio \le 2.3) \cdot (ratio > 2.0) \\ 0.242 \text{ if } (ratio \le 2.5) \cdot (ratio > 2.3) \\ 0.249 \text{ if } (ratio \le 2.8) \cdot (ratio > 2.5) \\ 0.258 \text{ if } (ratio \le 3.0) \cdot (ratio > 2.8) \\ 0.263 \text{ if } (ratio \le 4.0) \cdot (ratio > 3.0) \\ 0.281 \text{ if } (ratio \le 5.0) \cdot (ratio > 4.0) \\ 0.305 \text{ if } (ratio \le 7.5) \cdot (ratio > 5.0) \\ 0.312 \text{ if } (ratio \le 10.0) \cdot (ratio > 7.5) \\ 0.333 \text{ otherwise} \end{array} \right.$$

For "thin walled" sections" box sections torsion constant is calculated as follows

$$j := 1 .. 4 \qquad CS(A, ds, t) := \frac{4 \cdot A^2}{\displaystyle\sum_j \frac{ds_j}{t_j}}$$

STEEL GIRDER DECK - 25m/31m Span

Steel Girders

Thickness of walls of steel box

$t_j :=$

$21 \cdot mm$
$16 \cdot mm$
$21 \cdot mm$
$16 \cdot mm$

Length of steel box sides:

$ds_j :=$

$837 \cdot mm$
$1500 \cdot mm$
$1260 \cdot mm$
$1500 \cdot mm$

Area enclosed within median:

$$A := \left(ds_2 - \frac{t_1 + t_3}{2}\right) \cdot \frac{ds_1 + ds_3}{2}$$

$$A = 1.551\ m^2$$

This gives the torsion constant for the steel box:

$$CSB := CS(A, ds, t) \qquad CSB = 0.03347\ m^4$$

Concrete Deck Slab

Calculate torsion constant based on rectangular elements

Haunch Slab

Effective length of short side $b := 450 \cdot mm$

Effective length of long side $b_{max} := 1950 \cdot mm$

$k := k1\left(b_{max}, b\right)$ $k = 0.281$

$C1 := C\left(k, b, b_{max}\right)$

$C1 = 0.05\ m^4$

Cantilever Slab

Effective length of short side $b := 350 \cdot mm$

Effective length of long side $b_{max} := 2538 \cdot mm$

$k := k1\left(b_{max}, b\right)$ $k = 0.305$

$C2 := C\left(k, b, b_{max}\right)$

$C2 = 0.033\ m^4$

Central Slab	Effective length of short side	$b := 300 \cdot mm$
	Effective length of long side	$b_{max} := 1862 \cdot 2 \cdot mm$
	$k := k1\left(b_{max}, b\right)$	$k = 0.333$
	$C3 := C\left(k, b, b_{max}\right)$	
	$C3 = 0.033\ m^4$	
Total torsional constant for slab	$Cslab_{total} := C1 \cdot 2 + C2 \cdot 2 + C3$	
	$Cslab_{total} = 0.2\ m^4$	

Total Composite Torsional Constant

$$C_{TOTAL} := Cslab_{total} + 2 \cdot CSB \cdot \alpha_c$$

$$C_{TOTAL} = 0.72\ m^4$$

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Project: **Detailed Design Study of**
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Balaraja Flyover
Torsion Properties

STEEL COPING FOR OUTRIGGER PIER - P4 & P5

IN SPAN SECTION

Thickness of walls of steel box

$$t_j := \begin{pmatrix} 25\cdot mm \\ 19\cdot mm \\ 25\cdot mm \\ 19\cdot mm \end{pmatrix}$$

Length of steel box sides:

$$ds_j := \begin{pmatrix} 2100\cdot mm \\ 1900\cdot mm \\ 2100\cdot mm \\ 1900\cdot mm \end{pmatrix}$$

Area enclosed within median:

$$A := \frac{1}{2}\cdot\left(ds_2 - \frac{t_1 + t_3}{2}\right)\cdot\frac{ds_1 + ds_3}{2}$$

$$A = 1.969\ m^2$$

This gives the torsion constant for the steel box:

$$CSB := CS(A, ds, t) \qquad CSB = 0.04213\ m^4$$

SIDE SPAN SECTION

Thickness of walls of steel box

$$t_j := \begin{pmatrix} 21\cdot mm \\ 19\cdot mm \\ 21\cdot mm \\ 19\cdot mm \end{pmatrix}$$

Length of steel box sides:

$$ds_j := \begin{pmatrix} 2000\cdot mm \\ 1900\cdot mm \\ 2000\cdot mm \\ 1900\cdot mm \end{pmatrix}$$

Area enclosed within median:

$$A := \frac{1}{2}\cdot\left(ds_2 - \frac{t_1 + t_3}{2}\right)\cdot\frac{ds_1 + ds_3}{2}$$

$$A = 1.879\ m^2$$

This gives the torsion constant for the steel box:

$$CSB := CS(A, ds, t) \qquad CSB = 0.03617\ m^4$$

CONCRETE COPING FOR EXPANSION PIER

Calculate torsion constant based on rectangular elements

Upper section

Effective length of short side $b := 700 \cdot mm$

Effective length of long side $b_{max} := 1400 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.216$

$C1 := C(k, b, b_{max})$

$C1 = 0.104\ m^4$

Lower Section

Effective length of short side $b := 700 \cdot mm$

Effective length of long side $b_{max} := 3100 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.281$

$C2 := C(k, b, b_{max})$

$C2 = 0.299\ m^4$

Total torsional constant
for coping

$C_{coping} := C1 + C2$

$C_{coping} = 0.403\ m^4$

ABUTMENT

Calculate torsion constant based on rectangular elements

Column section

Effective length of short side $b := 1150 \cdot mm$

Effective length of long side $b_{max} := 1150 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.141$

$C1 := C(k, b, b_{max})$

$C1 = 0.247\ m^4$

Lower Section

Effective length of short side $b := 400 \cdot mm$

Effective length of long side $b_{max} := 4200 \cdot mm$

$k := k1(b_{max}, b)$ $k = 0.333$

$C2 := C(k, b, b_{max})$

$C2 = 0.09\ m^4$

Total torsional constant for coping

$C_{coping} := 2C1 + C2$

$C_{coping} = 0.583\ m^4$

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Project: **Detailed Design Study of**
North Java Corridor Flyover Project

Calculation: **Detailed Design Substructure**
Balaraja Flyover
Composite Bored Piles & Coloumn Torsion Properties

Initial Data

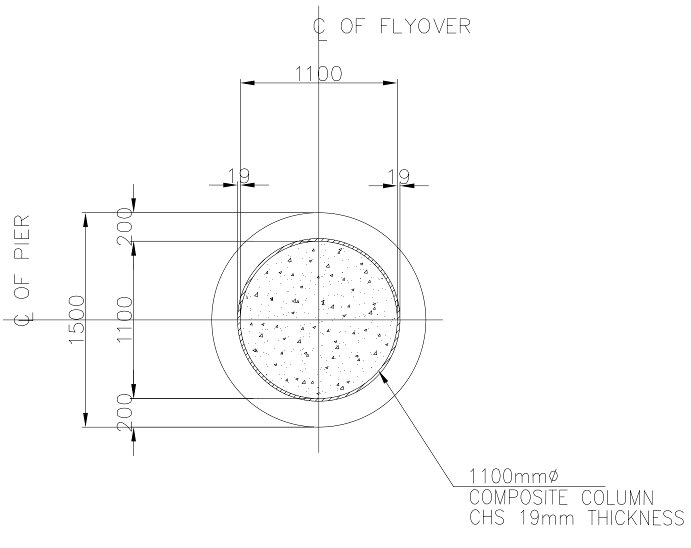
Modulus of elasticity of steel $E_s := 200000 \cdot MPa$

Characteristic strength of RC concrete $f_c := 30 \cdot MPa$

Modulus of elasticity of concrete $E_c := 4700 \cdot \sqrt{\frac{f_c}{MPa}} \cdot MPa$ $E_c = 25743\,MPa$

Modular ratio wth respect to concrete $\alpha_c := \frac{E_s}{E_c}$ $\alpha_c = 7.769$

Coposite Coloumn Dia 110 cm section properties respect to center point



Solid Concrete Coloumn diameter $D_c := 1.1m$

Casing thicknes $t_s := 19mm$

Steel Casing Outer Diameter $D_s := D_c + 2.t_s$

$D_s = 1.138\ m$

Area of solid Concrete

$$A_c := \frac{1}{4} \cdot \pi \cdot D_c^{\,2}$$

$$A_c = 0.95\ m^2$$

Area of Steel Casing

$$A_s := \frac{1}{4} \pi \cdot \left(D_s^{\,2} - D_c^{\,2}\right)$$

$$A_s = 0.067\ m^2$$

Combined Area - stress

$$A_{comp} := A_c + A_s \cdot \alpha_c$$

$$A_{comp} = 1.469\ m^2$$

Stiffness of Concrete Solid Circle

$$I_c := \frac{1}{64} \cdot \pi \cdot D_c^{\,4}$$

Stiffness Steel Casing

$$I_s := \frac{1}{64} \cdot \pi \cdot \left(D_s^{\,4} - D_c^{\,4}\right)$$

$$I_s = 0.01\ m^4$$

Combine stiffness Coloumn wrt to Concrete Ixx - Iyy

$$I_{comp} := I_c + I_s \cdot \alpha_c$$

$$I_{comp} = 0.153\ m^4$$

Torsional Constant Solid Concrete Circle

$$K_c := \frac{1}{2} \pi \cdot \left(\frac{D_c}{2}\right)^4$$

$$K_c = 0.144\ m^4$$

Torsional Constant Steel Casing Hollow concentric circular

$$K_s := \frac{1}{2} \pi \cdot \left[\left(\frac{D_s}{2}\right)^4 - \left(\frac{D_c}{2}\right)^4\right]$$

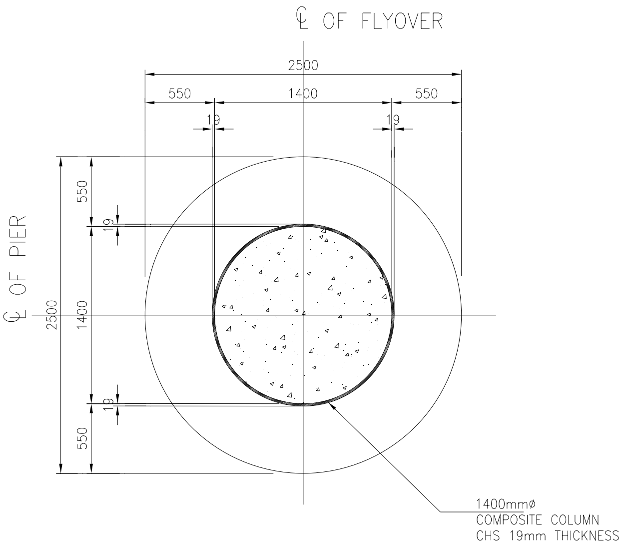
$$K_s = 0.021\ m^4$$

Combined Torsional constant wrt to concrete

$$K_{comp} := K_c + K_s \cdot \alpha_c$$

$$K_{comp} = 0.306\ m^4$$

Coposite Coloumn Dia 140 cm section properties respect to center point



Solid Concrete Coloumn diameter $D_c := 1.4m$

Casing thicknes $t_s := 19mm$

Steel Casing Outer Diameter $D_s := D_c + 2.t_s$

$D_s = 1.438\ m$

Area of solid Concrete $A_c := \frac{1}{4}\cdot\pi\cdot D_c^{\,2}$

$A_c = 1.539\ m^2$

Area of Steel Casing $A_s := \frac{1}{4}\pi\cdot\left(D_s^{\,2} - D_c^{\,2}\right)$

$A_s = 0.085\ m^2$

Combined Area - stress $A_{comp} := A_c + A_s\cdot\alpha_c$

$A_{comp} = 2.197\ m^2$

Stiffness of Concrete Solid Circle $I_c := \frac{1}{64}\cdot\pi\cdot D_c^{\,4}$

Stiffness Steel Casing $I_s := \frac{1}{64}\cdot\pi\cdot\left(D_s^{\,4} - D_c^{\,4}\right)$

$I_s = 0.021\ m^4$

Combine stiffness Coloumn wrt to Concrete Ixx - Iyy

$I_{comp} := I_c + I_s \cdot \alpha_c$

$I_{comp} = 0.354\ m^4$

Torsional Constant Solid Concrete Circle

$K_c := \frac{1}{2}\pi \cdot \left(\frac{D_c}{2}\right)^4$

$K_c = 0.377\ m^4$

Torsional Constant Steel Casing Hollow concentric circular

$K_s := \frac{1}{2}\pi \cdot \left[\left(\frac{D_s}{2}\right)^4 - \left(\frac{D_c}{2}\right)^4\right]$

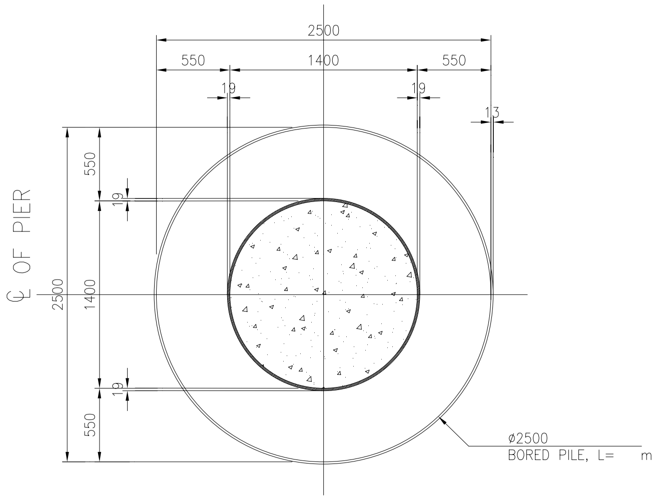
$K_s = 0.043\ m^4$

Combined Torsional constant wrt to concrete

$K_{comp} := K_c + K_s \cdot \alpha_c$

$K_{comp} = 0.708\ m^4$

Coposite Bored Piles Dia 250 cm section properties respect to center point



Solid Concrete Coloumn diameter $D_c := 2.5m$

Casing thicknes $t_s := 13mm$

Steel Casing Outer Diameter $D_s := D_c + 2.t_s$

$D_s = 2.526\ m$

Area of solid Concrete $A_c := \frac{1}{4} \cdot \pi \cdot D_c^2$

$A_c = 4.909\ m^2$

Area of Steel Casing

$$A_s := \frac{1}{4}\pi\cdot\left(D_s^{\,2} - D_c^{\,2}\right)$$

$$A_s = 0.103\ \mathrm{m}^2$$

Combined Area - stress

$$A_{comp} := A_c + A_s\cdot\alpha_c$$

$$A_{comp} = 5.706\ \mathrm{m}^2$$

Stiffness of Concrete Solid Circle

$$I_c := \frac{1}{64}\cdot\pi\cdot D_c^{\,4}$$

Stiffness Steel Casing

$$I_s := \frac{1}{64}\cdot\pi\cdot\left(D_s^{\,4} - D_c^{\,4}\right)$$

$$I_s = 0.081\ \mathrm{m}^4$$

Combine stiffness Coloumn wrt to Concrete Ixx - Iyy

$$I_{comp} := I_c + I_s\cdot\alpha_c$$

$$I_{comp} = 2.547\ \mathrm{m}^4$$

Torsional Constant Solid Concrete Circle

$$K_c := \frac{1}{2}\pi\cdot\left(\frac{D_c}{2}\right)^4$$

$$K_c = 3.835\ \mathrm{m}^4$$

Torsional Constant Steel Casing Hollow concentric circular

$$K_s := \frac{1}{2}\pi\cdot\left[\left(\frac{D_s}{2}\right)^4 - \left(\frac{D_c}{2}\right)^4\right]$$

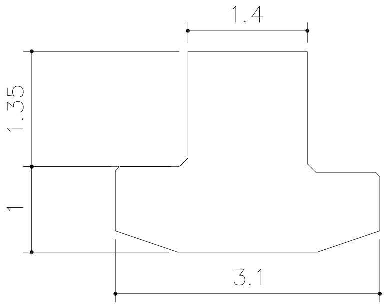
$$K_s = 0.162\ \mathrm{m}^4$$

Combined Torsional constant wrt to concrete

$$K_{comp} := K_c + K_s\cdot\alpha_c$$

$$K_{comp} = 5.094\ \mathrm{m}^4$$

COPING P6 TORSIONAL CONSTANT



Square Section

$a := \frac{1}{2} \cdot 1.35\text{m}$

$CR_1 := 2.25a^4$

$CR_1 = 0.467\ \text{m}^4$

Rectangular Section

$a := \frac{1}{2} \cdot 3.1\text{m}$ $\quad$ $b := \frac{1}{2} \cdot 1\text{m}$

$$CR_2 := a \cdot b^3 \left[\frac{16}{3} - 3.36 \cdot \frac{b}{a} \left(1 - \frac{b^4}{12 \cdot a^4} \right) \right]$$

$CR_2 = 0.824\ \text{m}^4$

Total Torsional Constant

$CR := CR_1 + CR_2$

$CR = 1.291\ \text{m}^4$

2.6 MATERIAL PROPERTIES

Material Properties

1) Structural steel

The type of structure steel shown below shall be used.

CLASS, DESIGNATION AND STRENGTH OF STRUCTURE STEEL

JIS Standard			ASTM Standard		
Designation	Yield Point (N/mm^2)	Tensile Strength (N/mm^2)	Designation	Yield Point (N/mm^2)	Tensile Strength (N/mm^2)
<u>G 3101</u>					
SS 400	215 – 245	400 – 510	A 36	250	400 – 500
<u>G 3106</u>					
SM 400	215 – 245	400– 510	A 242	290 – 340	≥ 430
SM 490	295 – 325	490 – 610	A440	290 – 340	430 – 480
SM 490 Y	325 – 365	490 – 610	A 441	290 – 340	430 – 480
SM 520	325 – 365	520 – 640	A 588	290 – 340	430 – 480
SM 570	420 – 460	570 – 720	A 572	410 – 450	510 – 550
<u>G 3114</u>					
SMA 400W	215 – 245	400 – 540			
SMA 490W	325 – 365	490 – 610			
SMA 570W	420 – 460	570 – 720	A 514	620 – 690	690 – 900

JIS G 3101 : Rolled Steel of General Structure
JIS G 3106 : Rolled Steel for Welded Structure
JIS G 3114 : Hot-Rolled Atmospheric Corrosion Resisting Steels for Welded Structure

2) Concrete

Concrete Compressive strength:

The 28-days compressive strength and corresponding elastic modulus Ec, shall be as shown below:

CLASSIFICATION OF CONCRETE (CYLINDER)

Concrete Class	Characteristic Compressive Strength MPa	Application of Structure
A-1	40	Pre-cast Pre-stressed Concrete Structure
A-2	35	Cast-in-situ Pre-stressed Concrete Structure
B-1	30	Deck slab, Pier heads and Columns, Diaphragms of P.C.I-Girder, Integral Abutments
B-2	30	Cast-in-situ Reinforced Concrete Piles, Bored Piles
C	20	Retaining Walls
D	15	Gravity type Retaining Walls
E	8	Leveling Concrete

Characteristic compressive strength of concrete shall be based on standard compression test of cylinder specimens at the stage of 28 days, as specified in JIS or ASTM.

The coefficient of thermal expansion shall be 1.0 x 10-5 (per o Celsius).

3) Reinforcing Steel

Reinforcing steel shall consist generally of high yield deformed steel bar of grade SD 40, and mild steel round bar SR 24 whenever bars must be bent / unbent and for special uses (dowels),

The type reinforcement, yield point, and application standard as shown below.

TYPE OF REINFORCEMENT

Type	Grade	Yield Point (N/mm^2)	Application standard		
			SII	JIS	BS
Round Bars	SR 24	240	SII 0136	G 3112	BS 4449
Deformed Bars	SD 40	390	SII 0136	G 3112	BS 4449

4) Pre-stressing Tendons

The type of pre-stressing of tendons shown below shall be used.

CLASSIFICATION OF PRE-STRESSING TENDONS

Notation	Utilization	Nominal Diameter (mm)	Yield Strength (kg/mm^2)	Braking Strength (kg/mm^2)	Application Standard	
					JIS	ASTM
PC Wire SWPR 1A	PC Pile	Ø 7	135	155	G 3536	A 421
PC 7 Wire Strand SWPR 7B	PC Hollow Core Slab Unit, PC Double Girder, PC I-Girder and T-Girder, Diaphragm of PC I-Girder and T-Girder	T 12.7	160	190	G 3536	A 416
PC 7 Wire Strand SWPR 7B	Transversal Cable for Deck Slab	T 15.2	160	190	G 3536	A 416
PC 19 Wire Strand SWPR 19	Diaphragm of PC I-Girder and T-Girder	T 19.3	160	190	G 3536	A 416

Modulus of elasticity: 2.0 x 105 MPa

Coefficient of thermal expansion = 1.2 x 10-5 (per o Celsius).

5) Elastomeric Bearing Pads

Bearings shall be desirably manufactured from natural rubber of IHRD 53 ± 5 hardness, having properties which comply with the Specification of Authority. The values of G and B, based on the assumed properties as shown below, may be used for natural rubber (using current formulations) for calculating the strain.

ELASTOMER PROPERTIES

Durometer Hardness IHRD ± 5	Shear Modulus G MPa	Bulk Modulus MPa
53	0.69	2,000
60	0.90	2,000
70	1.20	2,000

Allowable Stresses

1) Reinforced Concrete Structure

- Allowable stress for Bending

The basic allowable stresses calculated in accordance with the "Bridge Design Code" for concrete and reinforcing bars are shown below. The values shall be increased by the percentage of permissible overstress for each load combination given below.

BASIC ALLOWABLE STRESS OF CONCRETE (MPa)

Characteristic Concrete Strength fc'			15	20	25	30
Flexure Compression		0.4 fc'	6.00	8.00	10.00	12.00
Flexure Tension	Plain Concrete	0.15 √(fc')	0.58	0.67	0.75	0.82
	Reinforced Concrete	0.0	0.00	0.00	0.00	0.00
Bond Stress	Round Bars	---	---	0.70	0.80	0.90
	Deformed Bars	---	---	1.40	1.60	1.80
Bearing Stress		0.3 fc'	4.50	6.00	7.50	9.00

BASIC ALLOWABLE STRESS OF REINFORCING BARS

Grade	Yield strength fsy (MPa)	Allowable stress (MPa)	
		Tension 0.5 x fsy ≤ 170	Compression 0.5 x fsy ≤ 110
BJTD 40	390	170	110
BJTD 24	240	120	110

2) Pre-stressed Concrete Structure

a) Concrete

Allowable stress of concrete for pre-stressed concrete shall be in accordance with “Specification for Road Bridges”, 1996, Japan Road Association as shown below.

ALLOWABLE STRESS OF CONCRETE FOR PC STRUCTURE

Designation			Concrete Strength (MPa)				
			30.0	35.0	40.0	45.0	50.0
Compression Stress due to Bending	Immediately after pre-stressing	For Rectangular sections	15.0	17.0	19.0	21.0	21.0
		For T and Box sections	14.0	16.0	18.0	20.0	20.0
	Other Case	For Rectangular sections	12.0	13.5	15.0	17.0	17.0
		For T and Box sections	11.0	12.5	14.0	16.0	16.0
Compression Stress due to Axial Load	Immediately after pre-stressing		12.0	12.5	14.5	16.0	18.0
	Other Case		8.5	9.5	11.0	13.5	13.5
Tensile Stress due to Bending	Immediately after pre-stressing		1.2	1.3	1.5	1.8	1.8
	In case without Traffic Load		0.0	0.0	0.0	0.0	0.0
	Slabs and Joints between Pre-cast Segments		0.0	0.0	0.0	0.0	0.0
	Other Case		1.2	1.3	1.5	1.8	1.8
Tensile Stress due to Axial Load			0.0	0.0	0.0	0.0	0.0
Shear Stress	Shear and Torsion Considered Separately		0.8	0.9	1.0	1.2	1.2
	Shear and Torsion Considered Simultaneously		1.1	1.2	1.3	1.5	1.5
Bond Stress	Round Bars		0.9	0.9	1.0	1.0	1.0
	Deformed Bars		1.8	1.9	2.0	2.0	2.0

Prestressed reinforcement concrete member shall be designed in accordance with the "Specification of Road Bridges".

- **Limited Tensile stress without any cracks**

$ftk = M_1 x 0.23 x\ fck^{2/3} / \gamma c$

$M_1 = 0.6 / h^{1/3}$

Where:

ftk = Limited tensile stress

fck = Characteristic concrete strength

M_1 = factor for structural member

h thickness of structural member

In case of h = 1.2 m, fck = 35 MPa

M_1 = $0.6 / 1.2^{1/3}$ = 0.565

ftk = $0.565 x 0.23 x 35^{2/3} / 1.0$ = 1.39 N/mm^2

- **Crack-width Control**

Crack width can be calculated with the following condition

W = $\mathrm{K}_1 * \{4C + 0.7(Cs - \Phi)\}\{fse / Es(or\ \ fpe / Ep)\varepsilon' cs\}$

Where:

K_1 : Constant to take into account the influence of bond characteristic of steel
1.0 for deformed bars pre-tensioned Prestressing steel
1.3 for plain bars and post-tensioned Prestressing steel

K_1 = 1.0

C : Concrete Cover

Cs : Center to center distance of steel (cm)

Φ : Diameter of tensile steel (cm)

fse : Increase of tensile stress of reinforcement (kgf/cm2)

Es : Young's modulus of reinforcing steel (kgf/cm2)

fpe : Increase of tensile stress of Prestressing steel (kgf/cm2)

Ep : Young's modulus of Prestressing steel (kgf/cm^2)

$\varepsilon' cs$:Compressive strain for increment crack width due to shrinkage and creep of concrete usually = 0

Wa = $0.0035 x C$

b) Pre-stressing Tendons

Allowable stress of pre-stressing tendons shall be in accordance with the “Specification of Road Bridges” (JRA as follows, and the calculated values are shown below.

During pre-stressing : 0.80 fpu or 0.90 fpy whichever in smaller

After pre-stressing : 0.70 fpu or 0.85 fpy whichever in smaller

Under design load : 0.60 fpu or 0.75 fpy whichever in smaller

Where;

fpu = Tensile strength of tendon

fpy = Yield strength of tendon

ALLOWABLE STRESS OF PRE-STRESSING TENDONS (MPa)

	Nominal diameter	During pre-stressing	After pre-stressing	Under design load
PC wire SWPR 1 A	Ø 7	1215	1085	930
PC wire SWPR 1 A	Ø 8	1170	1050	900
PC 7-wire Strand SWPR 7 A	T 12.4	1350	1225	1050
PC 7-wire Strand SWPR 7 B	T 12.7	1440	1330	1140
PC 7-wire Strand SWPR 7 B	T 15.2	1440	1330	1140
PC 19-wire Strand SWPR 19	T 19.3	1440	1330	1140
PC bar SBPR 785 / 1030	Ø	720	680	600

3) Structural Steel

Allowable stress of the structural steel shall be in accordance with “Specification for Road Bridges”, 1996, Japan Road Association, as shown below.

ALLOWABLE STRESS OF STRUCTURAL STEEL

Structural Steel	SM 400	SM 490	SM 490 Y	SM 570
Yield Strength (N/mm^2)	235	315	355	450
Axial Tension (N/mm^2)	140	185	210	255

Structural Concrete Design

1) General

The reinforced concrete and pre-stressed concrete shall be designed in accordance with the definitions in these structural design criteria depending on type of concrete structure adopted.

2) Strength Reduction Factor

Strength reduction factor, Φ for concrete structural section shall be taken as shown below.:

STRENGTH REDUCTION FACTOR FOR ULTIMATE LIMIT STATE

Design Condition	Strength Reduction Factor Φ
Bending	0.80
Shear and Torsion	0.70
Axial Compression	
With spiral reinforcement	0.70
With hoops	0.65
Bearing	0.70

Design Strength of Concrete Structural Section

Design strength on structural concrete section for all loads and internal force, i.e bending moment, shear, axial force, and torsion, shall be based on design strength of section , is can be calculated from nominal strength multiplied by strength reduction factor

3) Minimum Concrete Cover to Reinforcement

Minimum concrete cover to outermost reinforcement shall be as follows:

Surface in contact with soil or water	: 75 mm
Columns	: 40 mm
Girders and Beams Cast-In-Situ	: 35 mm
Girders and Beams Pre-cast in Factory	: 25 mm
Slabs, Parapets, etc	: 30 mm

Structural Steel Design

1) General

The steel structure shall be designed in accordance with the definitions in these structural design criteria depending on type of steel structure adopted.

2) Strength Reduction Factor

Strength Reduction Factor, Φ for steel structural section shall be taken as shown in below.

STRENGTH REDUCTION FACTOR FOR ULTIMATE LIMIT STATE

Design Condition	Strength Reduction Factor Φ
a . Bending	0.90
b . Shear	0.90
c . Axial Compression	0.85
d . Axial tension	
1 . For yield tension strength	0.90
2 . For fracture tension strength	0.75
e . Shear Connection	0.75
f . Welding Connection	
1. Butt welding full penetration	0.90
2 .Throat welding and butt Welding partial penetration	0.75

Design Strength of Steel Structural Section

Design strength on section for all loads and internal force, i.e bending moment, shear, axial force, and torsion, shall be based on nominal strength multiplied by strength reduction factor.

3. SOIL PROPERTIES

3.1. SOIL PROFILE

3.2. SUMMARY OF SPT'S

3.3. SUMMARY OF UNDISTURBED TESTS

3.4. SUMMARY OF DISTURBED TESTS

3.5. SOIL SPRINGS AND LATERAL BEARING CAPACITY OBTAINED FROM SPT CORRELATIONS

3.1 SOIL PROFILE

Picture VII.1 Soil Profile